Low-Calorie Sweetened Beverage Consumption and Impact on Weight: A Systematic Review

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Abstract

The overconsumption of sugar-sweetened beverages (SSB) has frequently been targeted as a significant contributor to the high prevalence of overweight and obesity in the United States. Many American adults opt for low-calorie sweetened beverages (LCSB), such as Diet Coke, as a replacement. LCSB provide consumers with the sweetness of a traditional soda without the excessive caloric intake provided by added sugar. However, some researchers have called the use of LCSB into question, arguing that the consumption of LCSB may lead to weight gain rather than prevent it by disrupting metabolic responses, increasing one's preference for sweet substances, and decreasing feelings of satiety. The purpose of this systematic review is to evaluate whether there is an association between the consumption of LCSB beverages and impact on weight among adults. The PubMed database was used to identify studies relevant to the research question and inclusion criteria. Seven studies satisfied the inclusion criteria and were included in this review. The results of the studies were assessed and summarized narratively. The results were inconclusive; two randomized control trials indicated a negative association, four randomized control trials indicated no association, and one prospective cohort study reported a positive association between LCSB and body weight. Possible explanations for these findings and implications for future research are discussed.

Introduction

Overweight and obesity continue to jeopardize the health of American adults. Sixty-nine percent of adults aged 20 years or older are overweight or obese. Of these American adults, 36% are obese, with a body mass index (BMI) of 30 or greater (1). While the causes of overweight and obesity are extensive and complex, one contributing factor to the epidemic is the overconsumption of SSB. SSB are the single greatest contributor to excessive calorie and sugar intake in the average American's diet (2). Over time, the extra calorie ingestion may contribute to weight gain and obesity. Thus, reducing the consumption of SSB is one of several strategies promoted to prevent and reduce overweight and obesity in the US adult population.

In an effort to reduce SSB consumption and overall caloric intake, many individuals opt for LCSB as a replacement. Low-calorie sweeteners, also known as artificial sweeteners or non-nutritive sweeteners, are sugar substitutes that provide sweetness to beverages without increasing the calories of the drink (3). Examples of low-calorie sweeteners include aspartame, saccharin, and sucralose, which are often found in diet beverages, such as Diet Coke and Diet Pepsi, as well as sugar substitutes, such as Splenda and Sweet'n Low.

In recent years, the consumption of LCSB has increased among American adults. In 2008, 24.1% of adults reported consuming beverages containing low-calorie sweeteners (3). Low-calorie sweeteners are viewed as a safe alternative for adding sweetness to beverages without adding calories that could contribute to weight gain. However, some researches have questioned the effectiveness of consuming LCSB in an effort to reduce caloric intake and

decrease their risk for weight gain. Instead, some suggest that LCSB consumption may contribute to weight gain, despite the no-calorie nature of the drink, by disrupting metabolic responses, increasing one's preference for sweet substances, and decreasing feelings of satiety (4). The purpose of this systematic review is to evaluate whether there is an association between the consumption of LCSB and impact on weight among adults.

Literature Review

Overweight and obesity continue to pose a significant public health problem in America, threatening the health and livelihood of millions of American adults. In 2014, 36% of adults in the United States were obese, compared to 13.4% in 1960 (1). While overweight and obesity affect a substantial proportion of the adult population, obesity prevalence varies by gender, race, and age (1, 11). Higher rates of obesity are seen among adult women than men; thirty-eight percent of adult women are obese compared to 34.3% of men. The rates of obesity also vary by race. Asian adults have significantly lower rates of obesity compared to individuals of other racial backgrounds. Higher rates of obesity are seen among black adults and Hispanic adults, compared to non-Hispanic white adults (11). Additionally, middle-aged adults have higher rates of obesity compared to older and younger adults. Forty percent of middle-aged adults are obese, compared to 37% of older adults and 32.3% of younger adults (1).

While evidence suggests that rates of obesity may now be stabilizing, the prevalence of obesity still remains high and continues to pose a public health challenge in the United States (1). Overweight and obesity increases one's risk for numerous poor health outcomes. An adult who is overweight or obese has an increased risk for hypertension, Type 2 diabetes, stroke, cardiovascular disease, gall bladder disease, and cancers, amongst other adverse physical and psychosocial adverse health outcomes (2). The high prevalence of overweight and obesity combined with the numerous adverse health outcomes from these conditions call for continued attention to combat the nationwide problem.

Although the causes of obesity are complex, including genetic, environmental, and behavioral factors, the consumption of SSB has been implicated as a significant contributor to the high prevalence of overweight and obesity seen in today's population. A study examining diet patterns and long-term weight gain found that consumption of SSB was positively associated with increased weight over a 4-year time frame (5). According to the Centers for Disease Control, 6 out of every 10 adults drink at least one SSB each day (6).

Not only are 60% of the adult population consuming at least one SSB each day, but the portion sizes of these beverages have increased significantly in recent decades. This means that consuming one beverage today results in a greater intake of calories than it did several decades ago (7). Prior to the 1950s, the standard size for a can of soda, the most common SSB, was 6.5 ounce; this increased to the 12 ounce can in the 1960s, the 20 ounce bottle in the 1990s, and even large sizes found today (7). A study on changes in beverage intake from 1977 to 2001 found that overall caloric intake from SSB increased 135% (8). Americans consume larger portions of SSB and more SSB per day than in previous decades. In 1977, SSB consumption composed 2.8% of total caloric intake; this rose to 7.0% in 2001, which represents an increase from 50 calories to 144 calories during this time frame (8).

In efforts to avoid the extra calories— and possible weight gain— that may result from consuming SSB, many individuals opt for replacing sugary drinks with LCSB as an alternative. Twenty-four percent of adults reported consuming beverages containing low-calorie sweeteners, including no-calorie diet beverages and calorie-reduced beverages, in 2008; this is an increase from 18.7% in 2000. (3). Fifteen percent of adults report consuming zero-calorie diet beverages sweetened with low-calorie sweeteners, with overweight and obese adults consuming more LCSB than normal weight individuals (21). Low-calorie sweeteners provide sweet flavor to

beverages without the added, nutrient-poor calories provided by sugar. Since LCSB provide virtually no additional calories to a person's daily intake, LCSB do not directly contribute to weight gain. However, some researchers argue that, rather than preventing or reducing overweight and obesity, the consumption of LCSB may instead contribute to weight gain over time through indirect mechanisms, such as disrupting metabolic patterns of energy regulation, increasing preference for sweet substances, and decreasing satiety (4, 9).

Researchers who critique the consumption of LCSB point to the understanding that weight gain is more complicated than the simple calculation of ingested calories minus expended calories due to the complex metabolic pathways that contribute to changes in one's weight. While LCSB provide no increased caloric intake, some suggest that the consumption of low-calorie sweeteners may disrupt physiologic responses that are important for regulating metabolism. This hypothesis is based upon experiments conducted on laboratory rats (12). Researchers hypothesize that when an individual consumes a sweet substance, the sweetness level allows the body to predict the energy content (12). Consuming a substance with a sweet taste indicates to the body that the substance has a higher caloric content and allows the body to give an appropriate metabolic response. LCSB, however, provide sweet taste without the high caloric content that typically accompanies a sweet substance. Some researchers believe that disconnect between sweet taste and caloric intake provided by the consumption of LCSB has the possibility to disrupt energy regulation pathways, which may eventually make energy regulation less effective. Researchers posit that regular consumption of low-calorie sweeteners decouples the relationship between sweet taste and the triggering of an appropriate metabolic response. As a result, this could potentially lead to less effective energy regulation, slowed metabolic responses, and weight gain in the long term (12). In support of this hypothesis, researchers point

to results from laboratory studies conducted with rodent models. Specifically, researchers found that rats that consumed low-calorie sweeteners consumed more calories and increased their body weight more than rats that consumed sugar substances (9).

Several studies conducted on human subjects focused on evaluating these potential metabolic consequences of uncoupling sweet taste and calorie content through the consumption of LCSB (22). In one study, subjects were instructed to consume an allotted amount of a beverage sweetened with a low-calorie sweetener, a beverage sweetened with sugar, or water, which was used as the baseline measure. Following consumption, researchers evaluated the subjects' motivation to eat and food preferences. Consumers of the sugar-sweetened drink reported decreased motivation to eat and decreased food preferences. In comparison, consumers of the low-calorie sweetened drinks reported higher motivation to eat and an increase in food preferences following consumption. The researchers hypothesize that the low-calorie sweeteners may increase appetite through possible physiological mechanisms caused by stimulating sweet receptors (22). However, similar studies on humans have found contradictory results in which ingestion of LCSB did not lead to increased hunger and food intake (23).

In addition to the possible disruption of metabolic responses, some researchers suggest that the consumption of LCSB may also impact one's psychological choices, possibly leading to an increased preference for sweeter and higher calorie substances at a later meal (9). In one experiment, participants were randomized to receive a LCSB, a SSB, or water. Following the consumption of the beverage, participants were given the choice between a high calorie sugary snack, gum, or water. Participants who consumed the LCSB were three-times more likely to choose the high calorie, sugary snack than participants who consumed a SSB or water. A similar experiment was conducted to assess the effects of beverage type on satisfaction. Participants

were once again instructed to consume either a LCSB, SSB, or water. Following consumption, participants were permitted to eat as many cookies as they desired. Participants who consumed LCSB reported being less satisfied than those who consumed water or a SSB following consumption (9). These studies suggest that the consumption of LCSB may have an impact on an individual's food regulation psychology, which could potentially lead to greater caloric intake at a later meal and potential weight gain. However, similar studies assessing the impact of LCSB on reward and food intake have found opposing findings. For example, a study evaluating the reward value of LCSB compared to SSB found no significant differences between the two beverages when analyzed through behavioral assessment and functional magnetic resonance imaging to assess reward responses (24). In summary, the evidence supporting the impact of LCSB consumption on metabolic responses and food psychology has been mixed, with some studies indicating possible mechanisms linking LCSB to weight gain and other studies indicating no potential impact on weight.

The objective of this systematic review is to evaluate whether there is an association between LCSB consumption and impact on weight. The review intends to shed light on the use of LCSB as an alternative to SSB consumption for preventing and controlling overweight and obesity.

Methodology

The systematic review was conducted according to the guidelines established by Khan, Kunz, Klejinen, and Antes in their article "Five Steps to Conducting a Systematic Review" (10).

Framing the Question

The question guiding the systematic review began with the free-form research question: "Is there a relationship between the consumption of LCSB and impact on weight?"

The research question was further defined based on the population, exposures, outcome of interest, and study design. The population included adults of all weights, including normal, overweight, and obese individuals. The exposure was consumption of LCSB. The outcome of interest included changes in body weight and/or changes in body mass index (BMI). Acceptable study designs were those that compared consumers of LCSB with non-consumers in a prospective cohort study or randomized clinical trial.

Inclusion and Exclusion Criteria

The structured research question determined which studies were included in the review. Studies were excluded for several reasons, as summarized in Table 1. Due to the specific focus on the adult population, studies assessing children or adolescent consumption of LCSB were excluded. Additionally, studies that focused on or included low-calorie sweetened food items were excluded since the research question specifically pertained to beverage consumption. Studies were also excluded if they did not include body weight or BMI as a measured outcome.

For example, studies that analyzed LCSB consumption in relation to Type 2 diabetes, energy intake, and reward value were not included in the systematic review. Cross-sectional studies conducted at a single time point were excluded due to their inability to estimate possible weight-related effects over time.

Table 1: Criteria for Inclusion in the Systematic Review

Factor	Inclusion Criteria	Exclusion Criteria
Population	Adults: normal weight, overweight, obese	Children/Adolescents
Study Design	Prospective cohort , randomized clinical trial	Cross-sectional/descriptive studies
Exposures	Consumption of LCSB	Did not include LCSB, assessed foods with LCS
Outcome	Change in body weight, BMI	Type 2 diabetes, reward value, energy intake/compensation

Identifying Relevant Work

The online database PubMed was used to identify studies that were relevant to the research question. The following terms were used to identify articles: artificial sweetener, non-nutritive sweeteners, low-calorie sweeteners, beverages, body weight, and body mass index. These terms were used in attempt to capture all possible studies pertaining to the structured research question.

The search of these terms yielded 575 hits in the PubMed database. The title and abstracts of these articles were assessed to determine relevance to the research question. Exclusions were

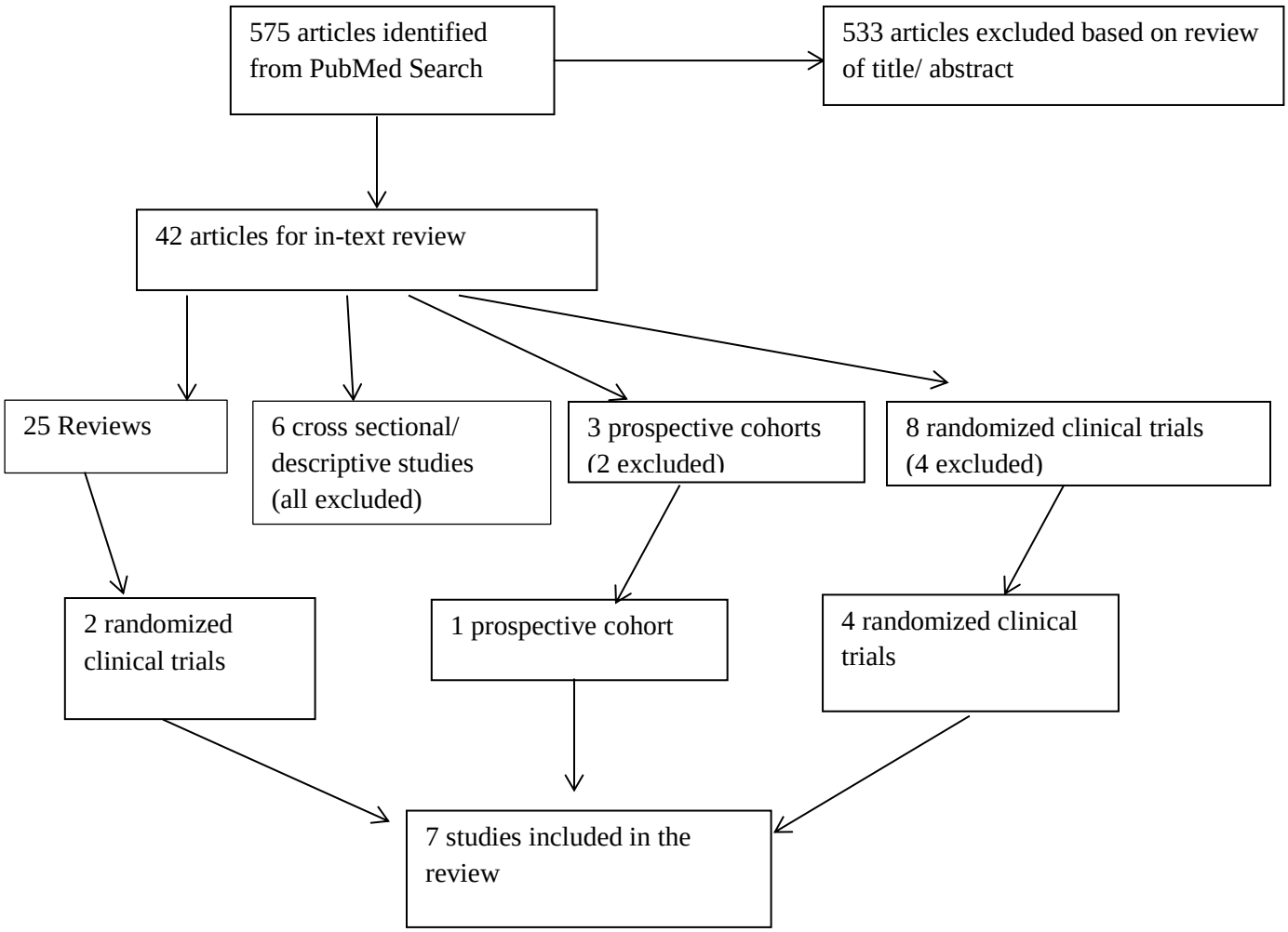
made according to the aforementioned criteria (Table 1). If the abstract did not provide sufficient information to clearly exclude the article, then the article was set aside for in-text review to assess whether it satisfied the inclusion criteria. Five hundred and thirty-three articles were excluded based on the title and abstract review, leaving 42 articles for further assessment.

The 42 remaining articles then underwent in-text review to assess whether they satisfied the criteria for inclusion in the systematic review. Of the 42 articles, 6 were cross-sectional/descriptive studies, 3 were prospective cohort studies, 8 were randomized control trials, and 25 were reviews or commentaries on the topic. The reviews and commentaries were evaluated to identify additional studies that may not have been captured in the PubMed search.

The six cross-sectional studies were excluded due to not fulfilling the study design criteria, which was restricted to prospective cohort studies and randomized clinical trials. Of the three prospective cohorts, two of them were excluded. One was excluded due to not measuring the outcome of body weight or BMI and the other was excluded for including consumption of low-calorie sweetened food. Of the eight randomized control trials, three were excluded for not measuring the outcome of body weight or BMI and one was excluded for including consumption of low-calorie sweetened foods. An evaluation of the reviews and commentaries produced two additional studies, both randomized clinical trials, which were not identified in the initial PubMed search.

In total, six randomized control trials and one prospective cohort study were included in the systematic review. Figure 1 shows the process for selecting articles to be included in the systematic review.

Figure 1: Process for Selecting Studies for Inclusion in the Systematic Review



Quality Assessment

In addition to meeting the inclusion criteria of population, outcome, and study designs, the studies included in the review were further assessed to determine their quality. The studies were evaluated according to the Critical Appraisal Skills Programme (CASP) checklist (20). Table 2 and Table 3 outline the quality assessment for the studies. The studies included in the systematic review were all of sufficient quality.

Table 2: Quality Assessment of Randomized Clinical Trials

Checklist Item	Peters et al	Tordoff et al	Reid et al	Reid et al	Tate et al	Maersk et al
Clearly stated research question	✓	✓	✓	✓	✓	✓
Randomized	✓	✓	✓	✓	✓	✓
Blinded		✓	✓	✓		
Similar groups	✓	✓	✓	✓	✓	✓
Equal treatment	✓	✓	✓	✓	✓	✓
All subjects accounted for	✓	✓	✓	✓	✓	✓

Table 3: Quality Assessment of Prospective Cohort Study

Checklist Item	Fowler et al
Clearly stated research question	✓
Acceptable recruitment	✓
Accurate exposure measurement	✓
Accurate outcome measurement	✓
Identified confounders	✓
Complete follow up	✓

Summarizing Results

Following selection, the seven studies underwent review to assess methodology, sample characteristics, exposure doses, outcomes, and results. The main findings of body weight and/or BMI outcomes were extracted for the results of the systematic review. The results were summarized narratively based on categorizing the main findings of the seven studies.

Results

The PubMed search resulted in seven studies that satisfied the inclusion criteria and where thus included in the review. Six of the studies were randomized control trials and one was a prospective cohort study. Table 4 summarizes the sample characteristics of each study (13-19). The studies ranged in sample size from 30 participants to 318 participants for the randomized clinical trials; the prospective cohort study had a sample of 3,371 participants. The studies varied by mean age, mean BMI, and sex of participants. The mean age of the samples ranged from 28 years-old to 48-years-old. The studies also varied by mean BMI and weight status at baseline, with a range of mean BMI of 22.4 to 36.3. Two randomized clinical trials examined participants of normal BMI (14, 16). The participants of the remaining five studies had a mean BMI that fell in the overweight/obese category (13, 15, 17-19). Of these studies, two of them were conducted in conjunction with a weight loss program for overweight/obese individuals (13, 17). Additionally, two of the studies explicitly focused on women (15, 16); of the other five studies, four of them had a larger population of women than men represented in their sample (13, 17, 18, 19). These sample characteristics are important for understanding the results of the systematic review and the implications of the findings.

Table 4: Sample Characteristics

Study	Sample, n	BMI, mean	Sex, %	Age, mean	Race, %
Peters et al (13)*	303	33.9	52 male 251 female	48.3	58% white 32% minority
Tordoff et al (14)	30	25.2	21 male 9 female	28.2	n/a***
Reid et al (15)	133	22.4	0 male 133 female	31.7	n/a***
Reid et al (16)	53	27. 5	0 male 53 female	33.7	n/a***
Tate et al (17)*	318	36.3	50 male 268 female	42	44% white 54% minority
Maersk et al (18)	47	32.1	17 male 30 female	38.7	n/a***
Fowler et al (19)**	3,371	27.4	1421 male 1950 female	44.1	n/a***

* indicates part of weight loss program
**indicates prospective cohort study
***n/a=not available

In addition to differences in sample characteristics, the studies also displayed differences in design. Table 5 displays the characteristics of the study designs. The duration of the randomized clinical trials varied from 3 weeks to 52 weeks. The prospective cohort study was conducted over a time period of eight years. The control groups of the studies also varied by substance and dose. Five of the randomized clinical trials had the participants in the comparison group consume SSB. In contrast, one of the randomized clinical trials had the comparison group consume water. While all participants in the consumer group consumed LCSB, the daily dose of the drink differed slightly amongst the studies. The dose ranged from 710 mL to 1200 mL of a LCSB per day. LCSB consumption was evaluated based on self-report method. The participants of the randomized clinical trials were instructed to consume the allotted servings and dose of the LCSB, which was provided in advance by the researchers. Compliance with the intervention was assessed with dietary logs and recall. In the prospective cohort study, LCSB was evaluated via

survey responses estimating how many LCSB the individual consumes per week. Each study included in the review measured change in BMI or body weight, with four studies measuring body weight as an outcome and three studies measuring BMI. Lastly, two randomized clinical trials were conducted in conjunction with a weight loss program that encouraged behavioral changes to aid weight loss, including increasing physical activity and improving eating habits (13, 17). It is important to note that the weight loss program could potentially confound the results and association between LCSB consumption and impact on weight. In the remaining five studies, the participants were not instructed to alter their eating patterns, aside the change in beverage consumption.

Table 5: Study Characteristics

Study	Duration	Control group	Consumer group	Dose/day	Outcome	Main Result
Peters et al (13)	52 wks	water	LCSB	710 mL	Body weight change	LCSB consumers decreased body weight
Tordoff et al (14)	3 wks	SSB	LCSB	1200 mL	Body weight change	No significant change in body weight of LCSB consumers
Reid et al (15)	4 wks	SSB	LCSB	1000 mL	Body weight change	LCSB consumers decreased body weight
Reid et al (16)	4 wks	SSB	LCSB	1000	BMI change	No significant change in BMI
Tate et al (17)	26 wks	SSB	LCSB	710-946 ml	Body weight chance	No significant change in body weight
Maersk et al (18)	26 wks	SSB	LCSB	1000 mL	BMI change	No significant change in BMI
Fowler et al (19)	8 yrs	Non-consumers	LCSB	n/a	BMI change	LSCB consumers significantly increased BMI

The main results of the studies are included in Table 6. Three main results were observed amongst the studies. First two randomized clinical trials found a statistically significant negative association between consumption of LCSB and body weight, one of which was conducted in conjunction with a weight loss program (13, 15). Second, four randomized clinical trials overall found no significant association between LCSB consumption and body weight (14, 16-18). Third, the prospective cohort study reported a significant positive association between LCSB consumption and body weight (19).

Table 6: Results

Study	Association	Significance	Sample
Peters et al (13)	Negative	P<0.0001	Overweight/obese in weight loss treatment program
Reid et al (15)	Negative	P<0.05	Normal weight women
Tordoff et al (14)	Negative: males None: females None overall	P<0.05 (males)	Normal weight
Reid et al (16)	None	-	Overweight women
Maersk et al (17)	None	-	Overweight/obese
Tate et al (18)	None	-	Overweight/obese in weight loss treatment program
Fowler et al (19)	Positive	P<0.0001	Normal, overweight, & obese in prospective cohort study

Looking more closely at these results, of the two studies that indicated a negative association between LCSB consumption and weight, one of them was conducted in combination with a weight loss treatment program for overweight/obese subjects (13). The study was assessing the effectiveness of LCSB consumption as a part of a weight loss program by comparing the difference between water consumption and LCSB consumption on weight loss and weight maintenance. Subjects who consumed LCSB lost significantly more weight and

better maintained the weight loss compared to subject who consumed water ($P < 0.0001$). The other study that reported a negative association between LCSB consumption and weight was conducted with participants of normal BMI (15). The authors note that the association between LCSB consumption on weight loss was statistically significant but marginal ($P<0.05$). In the study, more SSB consumers gained weight and more LCSB consumers lost weight during the 4-week treatment period. However, when the study was repeated amongst overweight women, the negative association between LCSB consumption and weight was not observed (16).

Four studies reported no significant association between LCSB consumption and impact on weight when compared to consumption of SSB. Three of these studies were conducted with overweight/obese subjects, with one of the studies conducted as part of a weight loss treatment program (16, 17, 18). These three studies conducted on overweight/obese participants found no significant differences in body weight between the LCSB consumer group and the comparison group. The results of the remaining study, which evaluated the effects of LCSB consumption on normal-weight subjects, also study found that drinking LCSB resulted in an insignificant change in body weight amongst consumers. However, when the results were analyzed based on sex differences, the results indicated that male participants lost significantly more weight ($P<0.05$) than females, while females who consumed LCSB did not experience a significant change in body weight (14).

The results of the prospective cohort study indicated a significant positive association between consumption of LCSB and weight ($P<0.0001$). The researchers found a positive dose-response relationship between LCSB consumption and weight gain amongst normal-weight and overweight/obese consumers (19). That is, the greater number of LCSB consumed per week, the greater the risk for overweight/obesity. The risk for overweight/obesity increased the most

between non-consumers and LCSB consumers in quartile 1, who consumed less than 3 LCSB per week ($P<0.0001$). The risk for overweight/obesity then continued to increase amongst LCSB consumers in quartile 1 to quartile 2 (3-10 LCSB per week), quartile 2 to quartile 3 (11-21 LCSB per week), and quartile 3 to quartile 4 (22+ LCSB per week). LCSB consumers in quartile 4, the highest quartile of LCSB consumption, experienced the greatest increase in BMI; individuals of this quartile exhibited a 78% increase in BMI compared to individuals who did not consume LCSB (19).

Discussion

LCSB are frequently consumed as an alternative to SSB, which have been shown to correlate with weight gain in American adults. Despite their no-calorie properties, some researchers suggest the LCSB consumption may indirectly contribute to weight gain through different metabolic and psychological processes. The systematic review was conducted to assess whether there is an association between the consumption of LCSB and impact on weight. The review yielded inconclusive results. No clear association was found between consumption of LCSB and body weight in adults.

A negative association was found between LCBS consumption and weight in two randomized clinical trials, one which was conducted during a weight loss treatment program and one which was conducted with individuals of normal body weight. The study conducted as a part of a weight loss treatment program compared LCSB consumption to water consumption (14). Compliance to the intervention was evaluated by reviewing daily logs of beverage intake; high rates of compliance were seen between both the LCSB group and water group. The results suggest that LCSB consumption may be an effective strategy for reducing weight when implemented as a part of a behavioral weight loss program for overweight/obese individuals. However, because the comparison group was restricted to water consumption, not SSB consumption, the results do not reveal whether LCSB are a suitable replacement for SSB as a method for reducing and preventing weight gain. Moreover, the weight loss program could have

confounded the negative association between LCSB consumption and weight, thus making it difficult to determine the specific impact of LCSB consumption on weight loss.

The other randomized clinical trial that found a negative association between LCSB consumption and impact on weight was conducted on normal weight women. Consumption was monitored using daily logs recording beverage intake during a four-week test period. The study reported significant but marginal effects of LCSB consumption on weight loss in comparison to SSB consumption, thus indicating that LCSB consumption may be beneficial for reducing weight gain in normal-weight women who consume SSB (15). On the other hand, when the study was replicated in overweight participants, no significant association was found between LCSB consumption and weight. (16) This finding suggests that LCSB consumption may be associated with decreased weight in normal-weight women, but not overweight women. One possible explanation for this finding is that the factors leading to overweight may be too complex to be reversed by simply replacing SSB with LCSB. Assuming a normal weight individual is physically active and maintaining a healthy diet, replacing a SSB with a LCSB may have a greater impact on weight due to the likelihood of resulting in decreased caloric intake. On the other hand, assuming an overweight individual may not maintain a physically active lifestyle and balanced diet, substituting a SSB with a LCSB may not have a significant impact on weight because it may not be substantial enough to compensate for pre-existing poor health behaviors. A study found that not only are overweight/obese individuals more likely to consume LCSB compared to normal weight individuals, but overweight/obese individuals also consume a similar amount of total caloric intake compared to overweight/obese individuals who consume SSB (21). These results indicate that switching from SSB to LCSB is not a substantial behavior change to result in weight loss amongst overweight/obese consumers.

Four randomized clinical trials reported no association between LCSB consumption and weight, all of which used SSB consumption as the control group. While one of the trials overall found no significant association between LCSB consumption and weight among normal-weight participants, when analyzed separately by sex, a significant negative association was observed among male participants during a three-week period (14). The three other studies that reported no association between LCSB consumption and weight were all conducted on overweight/obese subjects, one of which was conducted as part of a weight loss treatment program. These findings suggest that consuming LCSB as a replacement of SSB may not have an effect on weight amongst overweight and obese individuals but may have a weight-reduction effect on normal-weight males.

The prospective cohort study was the only study in the systematic review to indicate a significant positive association between LCSB consumption and weight. The results indicate a positive dose-response relationship between the consumption of LCSB and weight gain. Due to the study design, however, the findings cannot suggest a causal relationship between LCSB and weight; instead, they suggest a significant correlation between LCSB consumption and increased weight gain in the long-term.

In summary, the systematic review yielded inconclusive results regarding the relationship between LCSB and impact on weight. A significant positive association was recorded in a prospective cohort study, but due to the nature of the study, causality is difficult to determine. Of the six randomized control trials, two studies reported a negative association and four studies reported no association between LCSB consumption and impact on weight. Overall, the association between LCSB consumption and weight gain among adults is questionable as shown

through the results of this systematic review. The results of the systematic review indicate that there is no clear association between LCSB consumption and long-term weight gain.

Limitations

The systematic review has several limitations. The review was conducted by a single evaluator. An additional researcher would have been beneficial for discussing important decisions throughout the process of the review, such as determining inclusion criteria, selecting articles, conducting the quality assessment of the research studies, and summarized the results. Additionally, the review was conducted using a single database, PubMed, with English language restrictions. This restriction could have possibly excluded eligible studies. Lastly, a meta-analysis of the results was not performed, which could have enhanced the understanding of the association between LCSB consumption and impact on weight.

Implications

The inconclusive results of the systematic review call for additional studies, specifically randomized clinical trials, to evaluate the relationship between LCSB consumption and impact on weight. A study evaluating the consumption of LCSB as a replacement of SSB in participants of all bodyweights would be helpful for further understanding the role of LCSB in the American diet.

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